C

A study conducted at the Norwegian University of Science and Technology disproves the idea that math skills are innate by looking at how each individual math skill is attained. Researchers tested how well participants performed nine types of math tasks and found little to no correlation between being good at one skill versus another. For example, someone who can add fluently may not be good at word problems or geometry. Each math skill requires a different type of thinking, so one must practice each skill to be good at all of them. This understanding runs counter to the idea that math skills are innate, for if they were, those who are "good at math" would be naturally good at all math skills. The reality is that learners only master the math skills that they practice (Sigmundsson, 2014).

2. Fa e a e ab e (e e a)

Unlike most school subjects, mathematical concepts get progressively more difficult from kindergarten through 12th grade and beyond. To make matters worse, math requires very diverse skills ranging from number sense, algebraic thinking, spatial representations, and much more. No one will excel in all these areas without experience and practice, and eventually, every math student will face what might feel like an insurmountable hurdle in mathematics. At these moments, learners must decide if they have "run out" of the natural ability to perform math or if they can overcome the challenge with more effort and practice.

3. Sc a e a b

As mathematician, Paul Lockhart eloquently explains in his treatise, " L , "If I had to design a mechanism for the express purpose of destroying a child's natural curios13 TD[o)7 (3[w4b

How We Can Be Sure That a Gap Is Present

In his 1994 publication "The Psychology of Curiosity," George Lowenstein posits his information-gap theory of curiosity. According to Lowenstein, curiosity arises when there is a gap between what one knows and what one wants to know. Such information gaps produce the feeling of deprivation labeled curiosity. The curious individual is motivated to obtain the missing information to reduce or eliminate the feeling of deprivation (Lowenstein, 1994).

Lowenstein enumerates several stimuli that can induce curiosity, including presenting a riddle or puzzle, exposure to a sequence of events with unknown resolution, and violation of expectations. These stimuli are enhanced when an individual generates a prediction of the outcome. The desire to know if the prediction is correct compounds the level of curiosity.

It is important to note that if the individual has too much background knowledge, they may perceive the gap to be too small and not be as curious. Conversely, if the individual has too little knowledge, they may perceive the gap to be too large to overcome and not be curious. This makes the teacher's understanding of each child's background-knowledge crucial in the generation of maximal curiosity.

Fa e 3: *A*

Any time that educators can break expectations, curiosity will follow. In this case, the focus is on “controversial” questions. Choosing questions that expose common misconceptions are great fodder for arguments in math class.

Teachers can compound the effect by forcing students to make an initial guess. Their desire to know if they are right will motivate their learning.

Fa e 4:

Posing problems that are easily stated and have a fixed goal can allow for many different solutions strategies. This is how the best video games are designed. Players know the starting condition, the rules, and the end goal. They are free to obtain that goal in any way that they can—an open middle. Also, giving students control of their choices increases their motivation to learn.

In many cases, simply taking an existing problem and switching the givens with the unknown can make an exercise feel like a riddle or a puzzle, which increases curiosity.

The same problem with the givens and unknown swapped will result in an open question with many solutions.

Resource: openmiddle.com (Robert Kaplinsky)

Fa e 5:

Teachers are accustomed to posing all the questions in a mathematics classroom. One powerful way to spark curiosity is to present students with a scenario and

Ge C f ab e Be U c f ab e

There is a sense of discomfort when one tries to learn something new. Math teachers must recognize and acknowledge this feeling in their students, remind them that it is a natural feeling, and encourage them to push through.

A S de T e S e(d be e, f)

As discussed, students need opportunities to develop grit. When a student struggles to answer a question, teachers must resist the urge to swoop in and offer hints or solutions. Instead, they must allow students to try different solutions in the hope of finding a path forward. The idea is for kids to become comfortable with struggle, so they understand it is a normal part of learning.

Counterintuitively, the role of the teacher is not to provide answers; rather, it is to construct an environment in which students have the time and space to ask their own questions and develop a thirst for knowledge.

Rec el, e e

Students easily lose sight of their progress in mathematics. Imagine a student who begins the year with a B grade in mathematics. At the end of the year, he/she remains a B student. The student may falsely believe he/she has made no learning gains because the grade has remained constant. What students often fail to recognize is that the learning goals increase throughout the year. In actuality, a student whose grade didn't change has still made a great deal of progress!

One powerful way to emphasize this fact is to provide standards-based grades to students. Standards-based grading measures a student's proficiency against each standard. This rating can change as the student learns. Reporting progress in this way allows both the teacher and the learner to see exactly which standards have been mastered and which ones have yet to be attained. By contrast, traditional letter grades make it difficult to decipher which standards each student has mastered.

An additional and important feature of standards-based grading is to allow students to re-take assessments and change the grade for a particular standard. This reinforces the notion that learning is a process where perseverance and grit are rewarded. With traditional letter grades, students generally take a test, get a grade and the class moves on to the next unit. The traditional model implicitly teaches students that grades (and ability) are fixed and that mastery is not the primary goal.

STEP 3: PROMOTE A GROWTH MINDSET

G M d e

Stanford psychologist, Dr. Carol Dweck has identified two learning mindsets, which she calls “fixed mindset” and “growth mindset.” Dweck’s research on this topic is summarized in her excellent book, *L* .

A person with a fixed mindset believes that traits like intelligence are innate and cannot be changed. On the other hand, a person with a growth mindset believes that abilities can be improved with effort.

People with a fixed mindset would say Michael Jordan had an innate talent for basketball. People who believe in growth mindset might say that Michael Jordan practiced more often and more effectively than his peers and that is what led to his supreme ability and success.

If a student believes talent and ability are fixed, there’s a risk he or she won’t work as hard to improve.

M d e P edc Ac e e e

Dweck’s research has repeatedly shown that students with growth mindsets outperform those with fixed mindsets. Her team followed 373 students transitioning to 7th grade and monitored their math grades over the following two years. Their analysis showed significant improvement for students with growth mindset (Blackwell & Dweck, 2007).

The authors also note that “the impact of mindsets does not typically emerge until students face challenges or setbacks.” Growth mindset is a story we tell ourselves when we face setbacks. We are forced to ask ourselves, “Am I going to give up, because I’ve reached the limit of my talent, or will I push ahead, because I believe my efforts will lead to learning?”

H P eaG M d e

. Research shows that just knowing two mindsets exist can help children move toward the growth mindset.

. When a child goes home with an A on a math test, encourage parents to say, “I can see how your studying paid off. Great work,” rather than, “Wow! You’re so smart!” If a student got an A without much effort, try saying “Looks like that test was too easy for you. Maybe we can work on more challenging problems together.” This will teach them to value the process of learning more than the grades and that it’s OK to struggle.

. Students with a fixed mindset will try to hide their mistakes and make excuses to avoid trying because they are afraid to make mistakes. In their minds, mistakes are confirmation that they can’t do math instead of being just a natural part of the learning process.

. When students say, “I can’t” teachers should add the word, “yet.” This will reinforce the notion that learning is a process.

. Descriptive feedback is constructive, helpful information that answers the question, “How can I do better?” Descriptive feedback needs to clearly indicate to the student

Descriptive feedback answers the following questions:

- "Where am I now?"
- "What went well?"
- "Where am I going?"
- "How can I improve my work?"
- "What next?"

Teacher Mindset Matters

Dweck has also conducted research on the impact a teacher's mindset can have on students. Teachers were asked to provide feedback to 7th-grade students who had received a grade of 65% on an exam. Beforehand, half of the teachers had learned from a "scientific article" that math intelligence is fixed and half had learned that math intelligence is acquirable. Teachers who believed in a growth mindset were found to offer more encouragement and support, while also providing more strategies for improvement. Conversely, teachers with a fixed mindset were more likely to comfort the student by explaining that not everyone has math talent or that not everyone can excel in math.

Summary